

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently Amended) A variable compression ratio internal combustion engine, comprising:
 - an engine block defining at least one cylinder;
 - a head connected with said engine block, including an air intake port, and an exhaust port;
 - a piston slidable in each cylinder;
 - a combustion chamber being defined by said head, said piston, and said cylinder;
 - an air intake valve ~~controllably~~ movable to open and close the air intake port;
 - an air supply system including at least one turbocharger fluidly connected to the air intake port;
 - a fuel supply system operable to ~~controllably~~ inject fuel into the combustion chamber at a selected timing; [[and]]
 - a variable intake valve closing mechanism configured to keep the intake valve open by selective operation of the variable intake valve closing mechanism; and
 - a controller configured to operate the fuel supply system to supply a pilot injection of fuel before a main injection of fuel.

2. (Original) The engine of claim 1, further including an air intake valve assembly connected with said intake valve, said air intake valve assembly adapted to cyclically move said intake valve.

3. (Original) The engine of claim 2, wherein said air intake valve assembly includes a cam connectable with a rocker arm, said rocker arm being connected with said intake valve.

4. (Original) The engine of claim 2, wherein the variable intake valve closing mechanism is operated at least one of hydraulically, pneumatically, mechanically, and electronically.

5. (Currently Amended) A variable compression ratio internal combustion engine, comprising:

an engine block defining at least one cylinder;

a head connected with said engine block, including an air intake port, and
an exhaust port;

a piston slidable in each cylinder;

a combustion chamber being defined by said head, said piston, and said
cylinder;

an air intake valve movable to open and close the air intake port;

an air supply system including at least one turbocharger fluidly connected
to the air intake port;

a fuel supply system operable to inject fuel into the combustion chamber
at a selected timing;

a variable intake valve closing mechanism configured to keep the intake valve open by operation of the variable intake valve closing mechanism; and

~~The engine of claim 1, further including a controller configured to operate the intake valve to remain open for a portion of a second half of a compression stroke.~~

6. (Original) The engine of claim 1, wherein the fuel supply system includes a fuel injector assembly.

7. (Original) The engine of claim 6, wherein the fuel injector assembly is operated at least one of hydraulically, mechanically, and electronically.

8. (Original) The engine of claim 1, wherein the air supply system includes a second turbocharger arranged in series with the at least one turbocharger.

9. (Original) The engine of claim 1, wherein the at least one turbocharger includes a turbine and two compressors.

10. (Original) The engine of claim 1, wherein the at least one turbocharger has a pressure ratio of at least 4:1 with respect to atmospheric pressure.

11. (Currently Amended) A method of operating an internal combustion engine including at least one cylinder and a piston slidable in the cylinder, the method comprising:

imparting rotational movement to a first turbine and a first compressor of a first turbocharger with exhaust air flowing from an exhaust port of the cylinder;

imparting rotational movement to a second turbine and a second compressor of a second turbocharger with exhaust air flowing from an exhaust duct of the first

turbocharger;

compressing air drawn from atmosphere with the second compressor;

compressing air received from the second compressor with the first compressor;

supplying pressurized air from the first compressor to an air intake port of a combustion chamber in the cylinder via an intake manifold;

controllably operating a fuel supply system to inject fuel directly into the combustion chamber; and

selectively operating an air intake valve to open the air intake port to allow pressurized air to flow between the combustion chamber and the intake manifold during a portion of a compression stroke of the piston;

wherein said operating a fuel supply system includes operating the fuel supply system to inject a pilot injection of fuel before a main injection of fuel.

12. (Currently Amended) The method of claim 11, wherein said selectively operating an air intake valve includes operating a variable intake valve closing mechanism to interrupt cyclical movement of the intake valve.

13. (Currently Amended) The method of claim 11, wherein the selective operation of the air intake valve is based on at least one engine condition.

14. (Currently Amended) A method of operating an internal combustion engine including at least one cylinder and a piston slidable in the cylinder, the method comprising:

imparting rotational movement to a first turbine and a first compressor of a first turbocharger with exhaust air flowing from an exhaust port of the cylinder;

imparting rotational movement to a second turbine and a second compressor of a second turbocharger with exhaust air flowing from an exhaust duct of the first turbocharger;

compressing air drawn from atmosphere with the second compressor;

compressing air received from the second compressor with the first compressor;

supplying pressurized air from the first compressor to an air intake port of a combustion chamber in the cylinder via an intake manifold;

operating a fuel supply system to inject fuel directly into the combustion chamber;

and

operating an air intake valve to open the air intake port to allow pressurized air to flow between the combustion chamber and the intake manifold during a portion of a compression stroke of the piston;

~~The method of claim 11, wherein said selectively operating an air intake valve~~
includes operating the intake valve to remain open for a portion of a second half of the compression stroke of the piston.

15. (Currently Amended) The method of claim 11, wherein said controllably operating a fuel supply system includes operating a fuel injector assembly at least one of hydraulically, mechanically, and electronically.

16. (Currently Amended) An internal combustion engine, comprising:
a block defining at least one cylinder;
a head connected with said block, said head having an air intake port and an exhaust port;
a piston slidable in each cylinder;

an air intake valve controllably movable to open and close the air intake port;
a first turbocharger including a first turbine coupled with a first compressor, the
first turbine being in fluid communication with the exhaust port, the first compressor
being in fluid communication with the air intake port;
a second compressor being in fluid communication with atmosphere and the first
compressor;

a fuel supply system operable to controllably inject fuel into the combustion
chamber; and

a controller configured to selectively operate the air intake valve to remain open
during a portion of a compression stroke of the piston;

wherein the controller is configured to operate the fuel supply system to supply a
pilot injection of fuel before a main injection of fuel.

17. (Original) The engine of claim 16, wherein said second compressor is
coupled with said first turbine.

18. (Currently Amended) An internal combustion engine, comprising:
a block defining at least one cylinder;
a head connected with said block, said head having an air intake port and an
exhaust port;
a piston slidable in each cylinder;
an air intake valve controllably movable to open and close the air intake port;
a first turbocharger including a first turbine coupled with a first compressor, the
first turbine being in fluid communication with the exhaust port, the first compressor
being in fluid communication with the air intake port;

a second compressor being in fluid communication with atmosphere and the first compressor;

a fuel supply system operable to inject fuel into the combustion chamber; and
a controller configured to operate the air intake valve to remain open during a portion of a compression stroke of the piston,

~~The engine of claim 16, wherein the controller is configured to operate the intake valve to remain open for a portion of a second half of the compression stroke of the piston.~~

19. (Original) The engine of claim 16, wherein the fuel supply system includes a fuel injector assembly.

20-23. (Canceled).

24. (New) The engine of claim 1, wherein the main injection begins during a compression stroke of the piston.

25. (New) The engine of claim 1, wherein the main injection ends during a combustion stroke of the piston.

26. (New) The engine of claim 5, wherein the variable valve closing mechanism is operated hydraulically.

27. (New) The engine of claim 5, wherein the air supply system

includes a second turbocharger arranged in series with the at least one turbocharger.

28. (New) The method of claim 11, wherein the main injection begins during a compression stroke of the piston.

29. (New) The method of claim 11, wherein the main injection ends during a combustion stroke of the piston.

30. (New) The method of claim 14, wherein said operating an air intake valve includes hydraulically holding the intake valve open.

31. (New) The engine of claim 16, wherein the main injection begins during a compression stroke of the piston.

32. (New) The engine of claim 16, wherein the main injection ends during a combustion stroke of the piston.

33. (New) The engine of claim 18, wherein the engine is configured to hydraulically hold the intake valve open.

34. (New) A method of controlling an internal combustion engine having a variable compression ratio, said engine having a block defining a cylinder, a piston slidable in said cylinder, and a head connected with said block, said piston, said

cylinder, and said head defining a combustion chamber, the method comprising:

 pressurizing air;

 supplying said air to an intake manifold of the engine;

 maintaining fluid communication between said combustion chamber and the intake manifold during a portion of an intake stroke and through a portion of a compression stroke; and

 supplying a pressurized fuel directly to the combustion chamber during a portion of a combustion stroke.

35. (New) The method of claim 34, further including supplying the pressurized fuel during a portion of the compression stroke.

36. (New) The method of claim 35, wherein said supplying the pressurized fuel includes supplying a pilot injection at a predetermined crank angle before a main injection.

37. (New) The method of claim 36, wherein said main injection begins during the compression stroke.

38. (New) The method of claim 34, wherein said predetermined portion of the compression stroke is at least a majority of the compression stroke.

39. (New) The method of claim 34, wherein said pressurizing includes a first stage of pressurization and a second stage of pressurization.

40. (New) The method of claim 39, further including cooling air between said first stage of pressurization and said second stage of pressurization.

41. (New) The method of claim 34, further including cooling the pressurized air.

42. (New) The method of claim 34, wherein the maintaining includes holding an intake valve open hydraulically.

43. (New) The method of claim 34, wherein the maintaining includes operating a cam to open an intake valve and hold the intake valve open, and holding the intake valve open when the cam no longer holds the intake valve open.

44. (New) The method of claim 43, wherein said holding the intake valve open when the cam no longer holds the intake valve open includes holding the intake valve open hydraulically.

45. (New) An internal combustion engine, comprising:
a block defining at least one cylinder;

a head connected with said block, said head having an air intake port and an exhaust port;

a piston slidable in each cylinder;

a combustion chamber being defined by said piston, said cylinder, and said head;

an air intake manifold;

an air intake valve movable to open and close the air intake port;

an air supply system including at least one turbocharger fluidly connected to the air intake manifold; and

a fuel supply system operable to inject fuel into the combustion chamber;

wherein the engine is configured to control movement of the intake valve so as to maintain fluid communication between said combustion chamber and the intake manifold during a portion of an intake stroke and through a portion of a compression stroke of the piston; and

wherein the engine is configured to control the fuel supply system so as to inject fuel to the combustion chamber during a portion of a combustion stroke of the piston.

46. (New) The engine of claim 45, further including an air intake valve assembly adapted to cyclically move said intake valve.

47. (New) The engine of claim 46, wherein the intake valve assembly includes a cam associated with a rocker arm.

48. (New) The engine of claim 45, further including a variable intake valve closing mechanism operated hydraulically.

49. (New) The engine of claim 45, wherein the portion of the compression stroke is at least a majority of the compression stroke.

50. (New) The engine of claim 45, wherein the at least one turbocharger includes a first turbine coupled with a first compressor, the first turbine being in fluid communication with the exhaust port, the first compressor being in fluid communication with the air intake port; and wherein the air supply system further includes a second compressor being in fluid communication with atmosphere and the first compressor.

51. (New) The engine of claim 45, wherein the at least one turbocharger includes a first turbocharger and a second turbocharger, the first turbocharger including a first turbine coupled with a first compressor, the first turbine being in fluid communication with the exhaust port and an exhaust duct, the first compressor being in fluid communication with the air intake port, the second turbocharger including a second turbine coupled with a second compressor, the second turbine being in fluid communication with the exhaust duct of the first turbocharger and atmosphere, and the second compressor being in fluid communication with atmosphere and the first compressor.

52. (New) The engine of claim 45, wherein the engine is configured to operate the fuel supply system to supply a pilot injection of fuel before a main injection of fuel.

53. (New) The engine of claim 45, further including a rotatable cam operable to open the intake valve and hold the intake valve open; and

a variable intake valve closing mechanism configured to hold the intake valve open independent of the cam operating to hold the intake valve open.

54. (New) The engine of claim 53, wherein the variable valve closing mechanism is configured to hold the intake valve open after the cam opens the intake valve and when the cam no longer holds the intake valve open.

55. (New) The engine of claim 54, wherein the variable intake valve closing mechanism is operated hydraulically.

56. (New) A variable compression ratio internal combustion engine, comprising:
an engine block defining at least one cylinder;
a head connected with said engine block, including an air intake port, and an exhaust port;
a piston slidable in each cylinder;

a combustion chamber being defined by said head, said piston, and said cylinder;

an air intake valve movable to open and close the air intake port;

an air supply system including at least one turbocharger fluidly connected to the air intake port;

a fuel supply system operable to inject fuel into the combustion chamber at a selected timing;

a rotatable cam operable to open the intake valve and hold the intake valve open; and

a variable intake valve closing mechanism configured to hold the intake valve open independent of the cam operating to hold the intake valve open.

57. (New) The engine of claim 56, wherein the variable intake valve closing mechanism is configured to hold the intake valve open after the cam opens the intake valve and when the cam no longer holds the intake valve open.

58. (New) The engine of claim 56, wherein the variable intake valve closing mechanism is operated hydraulically.

59. (New) The engine of claim 56, further including a controller configured to operate the intake valve to remain open for a portion of a second half of a compression stroke.

60. (New) The engine of claim 56, wherein the fuel supply system includes a fuel injector assembly.

61. (New) The engine of claim 56, wherein the air supply system includes a second turbocharger arranged in series with the at least one turbocharger.

62. (New) The engine of claim 56, wherein the at least one turbocharger includes a turbine and two compressors.

63. (New) The engine of claim 56, wherein the at least one turbocharger has a pressure ratio of at least 4:1 with respect to atmospheric pressure.

64. (New) A method of operating an internal combustion engine including at least one cylinder and a piston slidable in the cylinder, the method comprising:

imparting rotational movement to a first turbine and a first compressor of a first turbocharger with exhaust air flowing from an exhaust port of the cylinder;

imparting rotational movement to a second turbine and a second compressor of a second turbocharger with exhaust air flowing from an exhaust duct of the first turbocharger;

compressing air drawn from atmosphere with the second compressor;

compressing air received from the second compressor with the first compressor;

supplying pressurized air from the first compressor to an air intake port of a combustion chamber in the cylinder via an intake manifold;

operating a fuel supply system to inject fuel directly into the combustion chamber; and

operating an air intake valve to open the air intake port to allow pressurized air to flow between the combustion chamber and the intake manifold during a portion of a compression stroke of the piston;

wherein said operating an air intake valve includes operating a cam to open the intake valve and hold the intake valve open, and holding the intake valve open when the cam no longer holds the intake valve open.

65. (New) The method of claim 64, wherein holding the intake valve open when the cam no longer holds the intake valve open includes hydraulically holding the intake valve open for a period of time.

66. (New) The method of claim 65, wherein the intake valve is held open for the period of time based on at least one engine condition.

67. (New) The method of claim 64, wherein said operating an air intake valve includes operating the intake valve to remain open for a portion of a second half of the compression stroke of the piston.